# Improving the Last Mile Logistics in a City Area by Changing Time Windows

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In the last decades, the number of vehicles delivering products in city areas has increased enormously. Not only the shops and companies in the area require a delivery of their ordered goods, but also the residents of the city which ordered their new products online. All these customers require a fast delivery within a tight time window. These time windows for the customers are adding an extra complexity to the routing planning problem of the delivery companies. Besides that, these time windows will often lead to an increase in transportation costs. For instance, when customers, which are located closely to each other, have very different time windows, the delivery company has to visit almost the same location twice, at different moments. This leads to extra transportation costs for the delivery company.

In this research, we investigate the possible savings that can be obtained when a delivery company has the ability to discuss possible changes in time windows with their customers. By tuning the time windows of customers, which are closely located to each other, the delivery company can save transportation costs. However, if the company changes some of the time windows, it might loose some goodwill by its customers. In this research, this is modeled by a fixed cost for changing a time window. There is a given budget or a given number of time windows that can be changed.

Furthermore, in this research, it is assumed that a set of customers is given. All these customers have every day a non-negative demand and, therefore, require to be served. This non-negative demand of a customer varies from day to day. Since the capacity of the available vehicles is limited, the routes for the vehicles will also differ from day to day. Moreover, the required service time window for a given customer is the same every day. This means that changes in the time windows will influence the routes of all days in the considered group of days.

The daily routing planning problem of the delivery company can be modeled by a Vehicle Routing Problem with Time Windows (VRPTW)[1]. In this problem, a set of customers with a non-negative demand is given and each of these customers requires a visit of one of the available vehicles within a given time window. To the best of our knowledge, the possibility of changing the customers' time windows is not yet studied in the literature. We call this new variant of

the VRPTW, the Vehicle Routing Problem with Changed Time Windows (VRPCTW). The objective of this new problem is to determine the best fixed number of time windows changes, such that all customers are served on each day of the considered group of days at minimal total transportation cost.

To determine the best time windows to change, we present a Two-Phase Heuristic, which can be extended with a Testing Stage. The two phases of the heuristic are the construction phase and the analysis phase. In the construction phase, for each day in the group of days, routes for the vehicles are constructed. This means that a VRPTW is solved for each day. To construct the routes for the vehicles, a Variable Neighborhood Search (VNS) is used. The applied VNS is based on the basic VNS of Hansen and Mladenovic [2]. In this construction phase, the time windows of the customers are assumed to be soft time windows. This means that customers can be served outside their given time window at a certain penalty cost. This penalty cost consists of a fixed part, which is equal to the fixed cost for changing a time window, and a variable part, which is based on the deviation from the service time of the given time window.

In the analysis phase of the heuristic, the constructed routes are analyzed to determine the best time windows to change. This determination is based on the penalty costs which are incurred in the constructed routes of the previous phase. Customers where large penalty costs are incurred at several days, are good candidates for changes in their time windows. Due to the interference of time windows of different customers, the Two-Phase Heuristic can be extended with a testing stage. In this testing stage, promising combinations of changes in time windows are tested by applying the VNS of the construction phase to the set of customers with adjusted time windows.

The presented solution approach is tested on a set of new benchmark instances based on the Solomon instances for the VRPTW [3]. Preliminary results show that by changing only a small number of time windows, the total transportation costs for the vehicles during the considered group of days can be decreased by around 3%.

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## References

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